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Biogas, renewable energy resource for Pakistan

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ABSTRACT

Developing countries are in critical energy crisis. Pakistan spends almost 7 billion US$ on import of fossil fuels annually to congregate its energy needs. The renewable and sustainable energy resources are best substitute to the conventional fuels and energy sources. Pakistan takes the opportunity to have almost 159 million animals producing almost 652 million kg of manure daily from cattle and buffalo only; that can be used to generate 16.3 million m^3 biogas per day and 21 million tons of bio fertilizer per year. That compensate approximately 20% of nitrogen and 66% of phosphorus required in the crop fields. Apart from this sugarcane industry has got the potential to generate 3000 MW energy. Domestic biogas plants were started in Pakistan in 1959 and at present there is significant number of such working units. Biogas Support Program (BSP) was started in 2000 by Pakistani government. So far it has achieved the target of installing 1200 biogas units, whereas another 10,000 units are expected to be set up in coming 05 years that will harvest almost 27% of country's biogas potential. A biogas unit of 10 m^3 size is anticipated to save almost 92,062 PKR per year on account of conventional fuels spent otherwise. Women's opportunity cost, with introduction of biogas units reportedly increased; subsequently impacting positively on household income. Biogas energy generation systems are in demand and their number is increasing steadily. They are low-cost and can be run with very small budget. Biogas energy corridor can work as a good substitute for nearly 70% of country's population residing in rural areas. Installation of plants to bottle the biogas can be additional opportunity. The need of a national policy is imperative to bring this technology at farmer's doorstep.

Contents

1. Introduction

Agriculture continues to play vital role in Pakistan's economy. Being the 2nd largest sector of the country, it contributes 21% toward the Gross Domestic Product (GDP) and involves 45% of labor altogether. Livestock is the largest depositor to the agriculture. It parts nearly 53.2% to the agriculture value-added, subsequently 11% to the GDP [1]. Energy is the major limiting factor and accountable for the setback in developing economies [2]. As a consequence of energy deficit, development in crop sector is hampered and growth rate of −2% has been recorded in Pakistan for 2009–2010 [1]. In Pakistan almost 20% of the foreign exchange is spent on import of fossil fuels [3]. Approximately 7 US$ billion on imports of conventional energy resources were spent equivalent to 40% of total imports by Pakistan [4]. Careful estimates show that by 2050 Pakistan's energy needs are expected to increase three times while, the supplies are not very inspiring [5]. It is imperative that alternate

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Table 1
Primary energy supply and per capita availability TOE = tons of oil equivalent E = estimated source: Pakistan Economic Survey 2009–2010.

Year	Energy supply		Per capita	
	Million (TOE)	Change (%)	Availability (TOE)	Change (%)
2005–2006	58.06	4.18	0.38	2.48
2006–2007	60.62	4.33	0.37	2.61
2007–2008	62.92	3.78	0.39	2.86
2008–09	62.55	−0.58	0.38	−2.27
July–March				
2008–2009	47.1		0.29	
2009–2010 E	46.8	−0.64	0.28	−3.09

Source: Pakistan Economic Survey 2009–2010.

Table 2
Strength of livestock in Pakistan.

Species	No. (Million)
Buffaloes	30.9
Cattle	34.3
Goats	59.9
Sheep	27.8
Camel	1.0
Equines	4.5

Source: Pakistan Economic Survey 2009–2010.

and renewable resources for energy must be explored [6]. Among all renewable resources biomass energy, i.e. biogas, is unique as its availability is de-centralized [7]. Almost all village households have animals and agro wastes to produce bioenergy. Biomass bonds almost 15% energy consumptions worldwide subsequently sharing 38% in developing countries [8]. In Pakistan, a household consuming biomass as sole energy source uses 2325 kg of firewood or 1480 kg of dung or 1160 kg of crop residues per annum approximately [9]. Expenses on these resources can be easily exchanged with a better and efficient source of renewable energy, i.e. biogas. Current paper aims at overviewing the energy supply situation and potential, history, recent situation, impact, models, limits and prospect of biogas in Pakistan.

2. Energy supply and demand situation

Pakistan is anticipated to act as energy corridor for the region as it holds important strategic location by bordering with Arabian Sea, India, China, Iran and Afghanistan. To keep-up this position Pakistan will have to strive for the energy self-sufficiency [10]. The energy supplies are much less and unable to meet the demand. Increased dependence on oil, liquefied petroleum gas (LPG) and imported electricity has been reported and the annual cumulative growth rate of oil, gas, LPG, coal, hydral electricity, nuclear electricity and imported electricity found to be 5.7%, 3.7%, 14.3%, 7.5%, 0.6%, −1.7% and 25.5%, respectively [11]. Similar results have been confirmed by Pakistan economic survey 2009–2010 [1]. Table 1 shows that change in supply of energy for year 2009–2010 was −0.64% and per capita availability of energy in tons of oil equivalent (TOE) reduced up to −3.09%. With current resources and pace Pakistan will have to face 29.06% of its energy deficit in 2021–2022. The Fig. 1 gives a clear forecast about energy supply and demand over the next decade [12].

European Union (EU) has legislated that each member country should be producing at least 22.1% of their electricity from renewable resources in order to stick to the commitment of producing energy from best alternative energy sources [13]. Pakistan, by following same code of conduct may fulfill its energy needs and satisfy the role of being an environment friendly nation.

3. Potential for biogas and fertilizer

Being an agro-livestock based economy; Pakistan has huge resources of biomass that are available in the form of crop residues, dung and feces, poultry litter, sugarcane bagasse and wood [5]. Electricity generation using biomass is one of the most convenient options, approximately 9 Giga Watts of electricity is generated from biomass worldwide. Pakistan is world's 5th largest sugarcane producer with an average annual production of 50 million tons cane and 10 million tons of bagasse. According to an estimate there are about 80 sugar mills having potential to generate almost 3000 MW energy through biogas generation but they are currently operating at 700 MW [12].

Livestock sector is growing at the rate of 4% annually [1]. There are almost 159 million animals and their manure can be used for generation of biogas in rural areas. Energy production by using animal feces is highly sustainable as it is economically viable, socially acceptable besides being environment friendly [14]. There are almost 65.2 million cattle and buffalo (Table 2) [1] assuming that an average animal can produce 10 kg of manure daily would account for almost 652 million kg of dung. If 50% of produced feces is collected and used for biogas production, it will be 326 million kg. According to an estimate about 20 kg wet mass of manure can generate 1 cubic meter (m^3) biogas [6] therefore producing almost 16.3 million m^3 biogas daily. Almost 112 million people in Pakistan are rural residents and biogas can meet their cooking and other energy needs in a good way. Pakistan can also explore biogas potential of citrus pulp, paper industry, slaughter house and street waste as well. Poultry waste is ideal substrate to produce biogas [15].

Rice straw, when used for biogas production in comparison with other resources like cotton gin, etc. was found best for methane production but when cotton gin mixed with livestock dung was fermented; it produced more gas in lesser time [16]. This clearly states that rice straw and cotton wastes can be used for electricity generation as well [15]. Apart from gas generation Pakistan has potential to produce 21 million tons of bio fertilizer per year [9]. A study shows that manure collected from cow farms has phosphorus value ranging between 4100 and 18,300 mg/kg of dry matter [17]. Another research showed that 57% of total manure produced was collectable and after considering all the losses 19% of the fresh manure nitrogen, 37% of phosphorus and 29% of potassium were available to plants and they could compensate almost 20% of nitrogen and 66% of phosphorus required in the fields [18]. Manure application can surely reduce the costs of chemical fertilizers and enhance the productivity of soil while acting as indirect energy source for the country.

4. History and current situation of biogas in Pakistan

Biogas industry is well developed in China and India. In China alone there were about 6.8 million household digesters and 1000 medium and big size digesters till 2007 with an estimated production of 2 million m^3, producing 5% of total gas energy in China [19]. In Tibet, residential biogas model (RBM) was introduced to harvest the potential of cattle wastes and it has impacted positively on socio-economic conditions of the area [27]. Individual attempts were made to develop biogas units in Pakistan; first ever documented biogas plant running with farmyard manure was built in 1959 in Sindh [20]. Domestic biogas plants gained Pakistani government's attention as alternate energy source in 1974 [4]. Pakistan Council for Appropriate Technology (PCAT) developed 21 biogas plants based on fixed dome Chinese type technology. These plants failed to perform due to gas leakage from hair line cracks in their structure. Later on Indian design was followed and 10 demo units were installed in Azad Jammu & Kashmir (AJK).

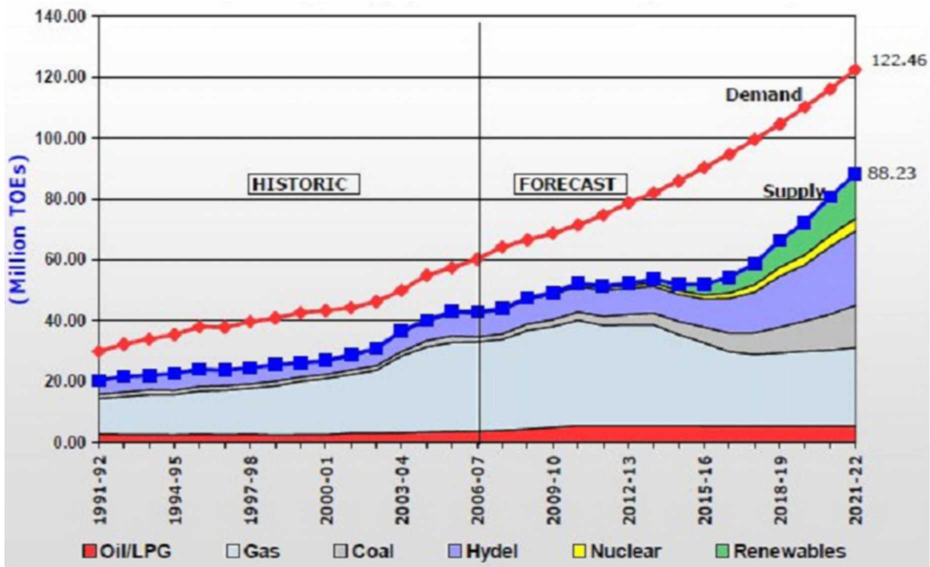


Fig. 1. Forecast of energy supply and demand in Pakistan.
Source: Power Generation from Sugar mills, evolving a business model, 2010.

These units worked well, hence; were adopted for mass propagation [21]. Meanwhile, Directorate General of New and Renewable Energy Resources (DGNRER) launched a project to establish 4000 biogas plants by 1986. This three tier program included 100 demonstration units sponsored by government, 2nd phase was on 50% subsidy and in 3rd phase subsidy ended with a continuing technical support to the willing people [4,21]. However, program failed due to withdrawal of government subsidy, high costs of technology, lack of proper training of the community members, insufficient demonstration and very low level motivation [9]. Biogas Support Program (BSP) was started in 2000 with the support of government of Pakistan to install 1200 household biogas units, the program has achieved its initial mandate and it is expected to install another 10,000 biogas plants in coming 5 years; it is expected to achieve 27% of total biogas potential of Pakistan [23]. Presently Pakistan Dairy Development Company (PDDC) has undertook biogasunits' installation in its Horizon-3 initiative with an aim to provide alternate renewable energy at very low cost to rural groups [24]. Up to May 13, 2009 almost 450 biogas plants were installed. However, due to overwhelming response this number jumped to 556 implementations soon after July, 2009 [25]. The expenses per biogas unit are reported between 35,000 and 40,000 PKR and manure of 4–6 buffaloes and/or cows is enough to run each of these domestic units. PDDC is providing 50% subsidy to the client farmers as well [24].

Another program started by Rural Support Programs Network (RSPN) in 2009 to construct biogas across the country; so far it has installed 70 biogas units in first year. People have choice to select from variety of unit sizes according to convenience and capacity; moreover a subsidy of RKR 7500 is also given to the clients [26]. Domestic Biogas Program is following Nepalese design of fixed dome known as GGC 2047 [26]. This technology has been promoted in Pakistan by leaflets, broachers, TV and Radio programs, farmer meetings and manuals [23]. Alternate energy development board is reviewing policies and working actively with all stakeholders to generate renewable energy from biomass [28]. Pakistan Council for Renewable Energy Technologies (PCRET) have reportedly installed almost 1500 household sized biogas units, 3 community size plants and 1 big thermophillic unit, but these units failed to work for a longer time and it would be wise to develop big sized biogas plants by following Japanese technique [10].

5. Economic benefits of using biogas over conventional fuels

According to an estimate, expenses on conventional biofuels like LPG, fuel wood, dung cakes, chemical fertilizer account for app. 3550 PKR while health maintenance costs account for 1000 PKR. Bio slurry can substitute chemical fertilizer to an amount of 600 PKR monthly [29]. Whereas in Community Organizations (COs) of Punjab have reported that biogas plants produced enough gas for their daily use and they found it far better than conventional biomass energy sources [30]. This clearly depicts the economic viability of biogas units as keeping in all above estimations; a biogas unit can save up to 5150 PKR monthly. Another source confirmed that a biogas digester of 10 m^3 showed saving of 7672 PKR monthly and 92,062 PKR as annual saving equivalent [31]. The total cost of 5 m^3 is 35,000 PKR hence per cubic meter cost of gas production is just 7000 PKR. [21]. It is established fact that cost of biogas plant cannot be reduced other than by using the biogas plant and the generated gas in an efficient way. A study on the "Optimal biogas plant size daily biogas consumption pattern and conventional fuel saving" indicated that whole quantity of dung collected from yards is not fed to the biogas digester, according to an estimate only 4.77 kg of dung/cubic meter of digester was being fed in Nepal, while the

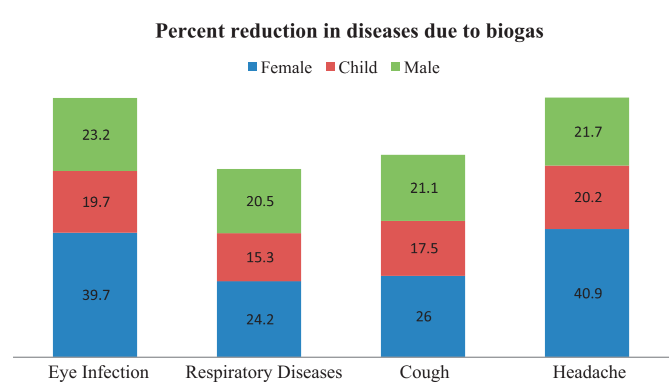


Fig. 2. Percent reduction in diseases due to biogas.
Source: Katuwal and Bohara [33].



Fig. 3. Movable gas holder.



Fig. 4. Fixed dome gasholder.

recommended quantities are reported to be 6 and 1.5 kg in hills and terai regions [32]. Among indirect benefits, considerable reduction in diseases was found, a study on such account was done in Nepal and showed sizable drop in ailments shown in Fig. 2 [33].

A study on residential biogas models in Panam, Tibet and China resulted that women's opportunity cost with conventional fuels was 47.09% to household income. With introduction of biogas units, household income increased subsequently impacting positively on opportunity cost contributed by women [27].

6. Biogas models

Plants with moveable gasholder, built-in fixed dome gasholder and low cost bag/balloon type are the 3 most common designs of biogas units working in Pakistan [21]. Movable floating drum type plants consist of a dome shaped gasholder made of some metal (Fig. 3). These units are easy to maintain and provide very steady gas pressure [34]. As fixed dome units work underground (Fig. 4); they are space efficient, need less maintenance but their construction needs special skills and gas pressure can be difficult to maintain. Bag balloon type units are not commonly used in the Country. PCRET, after long research and development has recommended two biogas unit sizes (5 m^3 and 3 m^3) sized for efficient biogas production at rural level [21]. Oversizing or the under feeding of dung and water to the digester are main causes of inefficiency. So moving to smaller sizes not only reduces the capital investment but also increase the efficiency [32].

7. Bottlenecks

There has been no clear policy from the government over renewable energy resources. Technical, physical, or information coordination and cooperation in stakeholders are missing. While High capital cost coupled with smaller capacity and less efficient models of biogas plants make them less acceptable. And Participation is restricted due to fewer demonstration units, very low motivation and less promotional activities [35]. Research studies showed that efficiency of biogas plants are being under utilized many of the farmers do not follow the recommended practices. A study shows that in Nepal 67.5% of plants observed received optimum water-feces ratio while 5% plants were being fed with lesser quantities of water and 27.5% units were fed with more than prescribed water quantities. This clearly reveals the fact that sufficient training is lacking on account of running such units [32]. Similar is the case with other developing countries, i.e. an Indian study has indicated that there is potential of almost 25,700 MW electricity generation from biomass but the actual production till 2007 was just 1227 MW that is just 4.47% of total potential [15]. Apart from these, maintenance services are less common and not easily accessible; gas leakage and low pressure are also factors responsible. Varieties of reasons make renewable energy resources less competitive as compared to conventional fossil fuels. So the government support is needed to make the alternative energy sources popular [35].

8. Conclusion

With rapid increase in population and industry, energy needs are on rise. Almost 7 million m^3 wood is used for commercial and domestic purpose annually in Pakistan [22] Biogas energy generation systems are in demand and their number is increasing steadily. They are cheaper and can be run with very low operating cost. This bio energy corridor can work as a good substitute for nearly 70% of

country's population residing in rural areas. Installation of plants to bottle the biogas can be another option. This will decentralize the source of energy and ensure uninterrupted power supply to the villages in Pakistan [23]. At present many agencies like PDDC, PCRET and RSPN are working to disseminate this renewable energy technology. But the need of a National policy is imperative to bring this technology at farmer's doorstep and boost its success rate.

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